

HISTORICAL MOA BONE COLLECTIONS (AVES: DINORNITHIFORMES) AT AUCKLAND MUSEUM—CLEVEDON AND KIA ORA

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Abstract. Auckland War Memorial Museum houses moa bones collected from swamp sites at Clevedon, South Auckland, in 1912, and at Kia Ora, North Otago, in 1930. Background to the discovery and excavation of these sites, gleaned from archival documents, is given, with an inventory of Auckland Museum's current holdings of specimens from these sites. The Clevedon collection comprises 280 bones belonging to at least 19 individual moas (16 *Anomalopteryx didiformis*, two *Pachyornis mappini* and one *Dinornis struthoides*) typical of a North Island wet forest site. The Kia Ora collection comprises 332 bones belonging to at least 51 individuals (17 *Emeus crassus*, 12 *Euryapteryx geranoides*, five *D. struthoides*, three *P. elephantopus*, one *D. giganteus* and 13 unidentified individuals). Documents have also established that the moa egg described by Gill & Cooper (2001) was found at Cromwell, Otago, before 1912.

KEYWORDS: Bird; ratite; Dinornithiformes; Holocene fossils; bones; New Zealand; South Auckland; Otago.

INTRODUCTION

Auckland War Memorial Museum has a collection of about 820 registered lots of moa bones (Aves: Dinornithiformes). Much of the collection was acquired by Sir Gilbert (G.E.) Archey, who was the museum's Director from 1924 to 1964, and who collected and studied moa bones in the 1930s as a basis for his monograph on moas (Archey 1941). At this time Archey obtained moa bone collections from Waikaremoana, the Waitomo area (King Country), Tokerau Beach (Northland), Mt Arthur (Nelson) and, it seems, Kia Ora (North Otago). However, the museum also has moa bone collections obtained earlier during T.F. Cheeseman's period as "Curator" (Director) from 1874 to 1923. These include collections from Whangarei (Northland) and Clevedon (South Auckland).

Most of these collections from particular sites were not described in detail at the time of discovery, nor have many of them been fully described since. Many of the older collections are poorly documented in the Land Vertebrates Department as to their precise localities and the circumstances of their collecting. I have therefore searched for correspondence and other documents in the archives of the Auckland Museum Library that cast further light on these moa collections. The purpose of this paper is to provide details of the fossil sites at Clevedon and Kia Ora, and to list the fossil bones identified in the Auckland Museum collection as being from these swamp sites. I have also obtained further documentation on the moa egg described by Gill & Cooper (2001).

In the inventories of the Clevedon and Kia Ora collections given in this paper, the total number of bones in each registered lot (x), and the minimum number of individuals represented by those bones (y) are given by the expression x/y . For each species, the x numbers for the individual lots are additive, but the y values are not. This is because the bones were presumably all found together in these swamp sites and the division of bones of the same species into lots is sometimes arbitrary (e.g. separation according to bone element) rather than according to individual birds. Values of y have been separately computed with all specimens of the species pooled.

The total length (mm) of undamaged leg bones is given. I measured lengths in an osteometric device (Archey 1941: 14, text-fig. 1) with the shaft of the bone parallel to the ruler. The length characters used here were those illustrated by Worthy (1987: 63, fig. 4), and the length of the tibiotarsus includes the cnemial crest. The presence of bones with signs of immaturity is noted.

NUMBERING OF MOAS AT AUCKLAND MUSEUM

It is uncertain whether and how early moa bones were registered at Auckland Museum. There are only five moa entries in the "Blue Book", which covers land vertebrates received up to 1917 (see Gill (1984, 1999) for further details of the departmental numbering systems). These entries are not for loose bones but for a "restoration", two articulated skeletons and two slabs with footprints. At least some moa bones received AV numbers under the card-cataloguing system for birds that was begun c. 1925. Others may have lost any record of an AV number when they were renumbered under later systems.

The main registration system for moa bones was the "Moa Record", an exercise book listing collecting details for moa bones that were given simple consecutive numbers starting at 1 (the first entry is actually for number 2). The entries to number 455 are in an unknown hand, followed by 456–468 in Archey's hand-writing, and 469–487 entered later by other staff members. This register was presumably used by Archey during his research on moas in the 1930s, and the numbers are those cited for Auckland Museum specimens in Archey's monograph (1941).

In 1966–67, L.J. Wagener reorganised the moa collection and renumbered the specimens with a species numbering system similar to the AV system used for other birds. Specimens were given numbers like 3.24 for the 24th specimen of moa species number 3. Duplicate 5 x 3 inch cards were filled out, one to be filed numerically and the other alphabetically by Latin name.

In 1983–84 the species numbering systems were abandoned. Birds, including moas, were renumbered with a simple consecutive number, often cited (as below) with the prefix B (for birds). During the renumbering of the moa bones in 1993–95, when all bones were checked and cleaned, lots were split into smaller units where this was warranted (e.g. separating immature bones from adult ones).

CLEVEDON, SOUTH AUCKLAND, 1912

The Clevedon site was discovered by a farmer (T.L. Smith) on his land and reported to a local amateur naturalist (H.S. Munro). Details are contained in:

(1) A letter to Cheeseman from H.S. Munro dated 17 September 1912 (Auckland Museum Library MA 95/41/4, AV2.4.17).

(2) A report in the *New Zealand Herald* of 25 September 1912 (p. 8) after a visit by Cheeseman to the site.

(3) An account that Munro wrote from memory in June 1946 ("Discovery of moa bones"; single-page typescript in Auckland Museum Land Vertebrates Department file).

The Clevedon discovery was discussed briefly by Buick (1931: 159) and Oliver (1949: 14, 29), probably based largely on the *N.Z. Herald*, and perhaps other, newspaper accounts. Bones from Clevedon were not mentioned in Archey's monograph (1941), perhaps in part because the bones were not then at Auckland Museum, but also because Archey paid most attention to sites that yielded associated bones of individual moas which the Clevedon site did not. Millener (1981) mentioned the site and its moa fauna briefly, as did Anderson (1989: 52, 214).

Hugh Sutherland Munro lived at Clevedon South when the bones were discovered, but by 1946 was living at Papakura. He was a brother of George Campbell Munro (1866–1963), who emigrated to Hawaii in 1890 where he became Honorary Associate in ornithology at the Bishop Museum, and wrote *Birds of Hawaii* (1944). H.S. Munro was also an uncle of H.R. McKenzie, who was part-time Associate Ornithologist at Auckland Museum, 1968–1972.

LOCATION

The site was “in the Clevedon district” (MA 95/41/4) and described as “a rich flat at the foot of a range of hills” (*N.Z. Herald*). Munro later gave the locality as “the foot of a range of hills, running from Maraetai to Papakura Valley” (1946 MS). The site cannot therefore be fixed precisely, but was clearly at the foot of the hills north, west or north-west of Clevedon. Clevedon was Site 99 of Millener (1981), who gave grid references R11/899656 and N42/530432, and listed it as having the Fossil Record Number R11/f28 (Geological Society of New Zealand).

DISCOVERY

“While draining & stumping a piece of swampy land [in July 1912] Mr T.L. Smith struck a layer of bones some four feet [1.2 m] from the surface & directly under the spot from which a three foot [0.9 m] white pine stump [*Dacrycarpus dacrydioides*] had been removed” (MA 95/41/4). Munro was not informed until some two months after the discovery, when he spent two days excavating bones. The bones were “in a heap”, intermixed with timber and “great quantities of stones of hinau [*Elaeocarpus dentatus*], miro [*Prumnopitys furruginea*] & parts of karaka berries [*Corynocarpus laevigatus*]” (MA 95/41/4). Munro thought it probably a Maori midden site. According to the *N.Z. Herald*, the farmer found the bones “within an area of some few square yards” while attempting to drain one of the natural springs in the area.

Munro's 1946 MS indicates that he took the bones to his home, 4 miles (6 km) from the site, where he washed them and spread them out to dry. When dry they were “sized with glue”. Some articulated skeletons were set up (Fig. 1).

An incomplete series of letters in the archive of the National Museum of New Zealand, Wellington, shows that Munro and Smith considered selling the moa bones overseas, and in 1917 offered them for sale to the museum in Wellington. However, the museum's offer, constrained by “the necessity for war economy”, was “a bit less” than the collectors' idea of their value. In 1926 it appears that Munro was seeking £2,000 for the collection. The Director of the Wellington museum advised the Under-Secretary for Internal Affairs that the collection was “doubtfully worth £100”, and recommended that no permit to export be given.

It seems that in 1946 Munro still had the collection, or part of it, at his home. The bones probably came to Auckland Museum later, perhaps in 1954 with other bird specimens collected by G.C. and H.S. Munro.

MOA FAUNA

In his 1912 letter (MA 95/41/4), Munro estimated the excavations to have yielded “upwards of forty birds varying in size from about one to nine feet [0.3–2.7 m] in height”. The bones



Fig. 1. Moa bones from the Clevedon site. Undated photograph of articulated skeletons and loose bones, apparently at the home of H.S. Munro in Papakura. The large skeleton (*Dinornis*) is not among the Clevedon bones currently recognised at Auckland Museum. Photo: Dr G. de Clive-Lowe (Auckland Museum Land Vertebrates Department).

were “considerably damaged, both during the draining & afterwards by cattle”.

Cheeseman, probably after further excavations, identified the bones as comprising 26 *Dinornis* (= *Anomalopteryx*) *didiformis*, 6 *D.* (= *Euryapteryx*) *curtus*, 1 *D. gracilis* (= *D. novaezealandiae*) and 1 *D. oweni* (= *Anomalopteryx didiformis* or *Pachyornis mappini*), making a total of 34 birds (*N.Z. Herald*). The large skeleton shown in Fig. 1 is probably the single specimen referred to *Dinornis gracilis*. According to the *N.Z. Herald* account, the deposit also contained gizzard stones, the largest stone weighing about 2 ounces (57 g), and tracheal rings. Oliver (1949: 14) stated that the site yielded about 900 bones representing 40–50 birds.

P.R. Millener examined the collection at Auckland Museum in 1978, and summarised the species composition (with minimum numbers of individuals) as: 20 *Anomalopteryx didiformis*, 10 *Euryapteryx curtus*, 2 *Pachyornis mappini* and 1 *Dinornis struthoides* (Millener 1981: 800). Labels in Millener’s hand identified particular bones (now numbered B7122–3) as *Pachyornis septentrionalis*, which is currently a synonym of *P. mappini* (Turbott 1990). I have identified

further Clevedon bones (now numbered B11079–81) as belonging, or possibly belonging, to this species. Distinctive features of *P. mappini*, compared with *Anomalopteryx didiformis*, include a more dorso-ventrally flattened pelvis and the presence of a pneumatic foramen at the proximal end of the femur on the ventral surface (Worthy & Holdaway 2002).

I identified three bones as belonging to *Dinornis struthoides* (now numbered B11078). All remaining bones from the site are listed as *Anomalopteryx didiformis*. I have checked the lengths of intact leg bones to make sure they fall within the established range for *A. didiformis*. All the femurs lack the pneumatic foramen of *P. mappini*, and none of the pelves are dorso-ventrally flattened. However, other bones like the tibiotarsus and tarsometatarsus are hard to identify, especially when damaged. Minor bones like vertebrae, phalanges and ribs have not been checked, or are impossible to check, for species identification.

L. Huynen (Massey University, Auckland) amplified DNA from a small sample drilled from a femur of both B7122 and B7123 (attributed to *Pachyornis mappini*), and found the DNA sequences to be similar to those of bones identified as *P. mappini* from other sites (D. Lambert and L. Huynen, pers. comm. 2003). The bones of *Euryapteryx curtus* that Millener identified are either missing, or among the bones ascribed to *A. didiformis*.

INVENTORY OF SPECIMENS

Bones in Auckland Museum believed to be from the 1912 Clevedon site are currently registered in the 13 lots listed below. They are catalogued from Clevedon, Papakura or without locality, and with or without the name H.S. Munro, G.C. Munro or just “Munro”. Nearly all the bones are stained a distinctive reddish brown, which is consistent with them all having come from the same swamp site.

In total, 280 bones from Clevedon are recognisable in the Auckland Museum collection, representing a minimum of 19 individual moas. Summary statistics for the largest samples of bone lengths are given in Table 1.

Anomalopteryx didiformis (Owen, 1844)

(264/16; minimum number of individuals based on a total of 16L tarsometatarsi)

B5841 (formerly 1.146; $x/y = 49/9$). 22 vertebrae; 7 thoracic ribs; sternum (partial); pelvic fragment; L tibiotarsus (shaft only, immature); 4L+9R fibulas; 4L tarsometatarsi (all damaged).

B5842 (formerly 1.160; 7/3). R femur; 3R tarsometatarsi; 3 phalanges. Immature; all long bones damaged.

B5843 (formerly 1.160; 153/9). 7 crania; 16 mandibles or mandibular fragments (minimum number of individuals = 9); 3 quadrates; tracheal ring; 2 thoracic vertebrae; 2 thoracic ribs; 2 pelves; L+R femurs (233 mm); 2L+3R tibiotarsi (all damaged); L+R fibulas; L+3R tarsometatarsi (159, 163, 168 mm); 92 non-ungual phalanges; 15 ungual phalanges. Remains of seeds of *Elaeocarpus dentatus* (hinau), *Prumnopitys ferruginea* (miro) and *P. taxifolia* (matai).

B5857 (formerly 1.148; 13/8). 5L+8R femurs (216, 235, 235, 244, 244, 246, 246, 248 mm plus 2 immature).

B5858 (formerly 1.148; 13/8). 5L+8R tibiotarsi (340, 374, 378, 380, 383, 404 mm).

B5859 (formerly 1.148; 17/7). 10L+7R tarsometatarsi (167, 168, 168, 174, 175, 177, 177, 177, 180, 182, 206, 207 mm plus 2 immature).

B5867 (former number not recorded; 12/3). 3L+3R femurs (all damaged or immature); 3L+2R tibiotarsi (370 mm, most damaged); L tarsometatarsus (177 mm).

Pachyornis mappini Archey, 1941

(10/2)

B7122 (former number not recorded; 8/1). Cranium; vertebra; pelvis; L+R femurs (150 mm); L tibiotarsus (246 mm); L+R tarsometatarsi (119 mm). Presumably associated bones of individual.

B7123 (former number not recorded; 1/1). L femur (164 mm).

B11081 (formerly 1.160; 1/1). Pelvis.

Pachyornis mappini?

(3/1)

B11079 (2/1). L+R tibiotarsi (288 mm). The bones seem to be a pair but one was formerly numbered 1.148 and the other 1.160.

B11080 (formerly 1.160; 1/1). Cranium.

Dinornis struthoides Owen, 1844

(3/1)

B11078 (formerly 1.148; 3/1). L+R femurs (249 mm), tarsometatarsus (shaft only). Immature.

Table 1. Summary statistics for bone lengths (mm) of moas from the Clevedon and Kia Ora swamp sites. Samples of five or greater only.

Element	mean	n	s.d.	range
CLEVEDON				
<i>Anomalopteryx didiformis</i>				
Femur	238.6	9	10.15	216–248
Tibiotarsus	375.6	7	19.10	340–404
Tarsometatarsus	176.6	16	13.29	159–207
KIA ORA				
<i>Emeus crassus</i>				
Femur	272.0	20	22.44	236–307
Tibiotarsus	456.7	17	37.99	387–512
Tarsometatarsus	208.2	25	20.06	177–242
<i>Euryapteryx geranoides</i>				
Femur	275.1	14	24.63	242–309
Tibiotarsus	475.5	16	45.41	397–531
Tarsometatarsus	209.1	12	12.39	186–221
<i>Dinornis struthoides</i>				
Tarsometatarsus	314.6	5	11.48	304–334

AGE

A bone collagen sample from specimen 1.160 (now B5843) was carbon-14 dated at 1315 ± 70 years BP (NZ4871C; Millener 1981: 482, 848). Records from the Institute of Geological and Nuclear Sciences (Lower Hutt, New Zealand) show that a right femur was dated, that the Conventional Radiocarbon Age was determined on the “new oxalic acid standard” and that the bone had 6.6% organic carbon (T.H. Worthy, pers. comm. 2003). This confirms the site as a natural late Holocene swamp-miring site unconnected with human activity.

KIA ORA, NORTH OTAGO, 1930

Auckland Museum has a collection of moa bones labelled from Kia Ora, which are not further documented by the cataloguing system and had to be listed by Worthy (1998: 507) as being without a collector or precise locality. A group of letters from 1930 (Auckland Museum Library MA 95/43/21, AV2.6.489) exchanged between Archey and Mr K.L. Warren, then a divinity student at Knox College, Dunedin, seems to provide a key to the missing information. Mr Warren discovered moa bones at a site 9 miles (14 km) west of Oamaru, which is clearly the Kia Ora area. The correspondence states that the bones were received by the museum. Auckland Museum has no other large assemblage of moa bones from Otago, so presumably the 1930 correspondence and the Kia Ora bones belong together, though there is no direct link.

“Beck’s farm” is given on labels as a location for three specimens (B6091, B6178, B11083), but this name does not appear in the correspondence. The farm where the bones were found changed hands in 1930 but the correspondence gives neither the old nor new owner’s name. Warren’s contact address while digging was c/o Mr William Freeman of Kia Ora, but this may not have been the farm containing the site.

Oliver (1949) made no mention of the Kia Ora site, and Archey (1941) mentioned it only once (p. 51; as a locality for *Emeus crassus*). T.H. Worthy examined the collection in 1991 and published a summary of its contents (Worthy 1998: 507).

LOCATION

Warren’s correspondence states that the moa bones were from a bog on a farm $3\frac{1}{2}$ miles (6 km) from Five Forks, 4 miles (6 km) from Enfield and 9 miles (14 km) west of Oamaru. This agrees with the site being at Kia Ora. In a short report, with map (Fig. 2), Warren described the site as being on the fringe of the limestone district. The site, at about 300 feet (90 m) above sea-level, was in a small natural catchment c. 1000 yards (900 m) by 600 yards (550 m). It was bounded to the north-west, south-west and south-east by low hills to 1200 feet (370 m). The site, “in a soakage area”, was “easily flooded, with no natural outlet for water except [a] series of bogs and water-holes which dry up in summer”. The Kakanui River was $3\frac{1}{2}$ miles (6 km) west in a neighbouring watershed.

Unfortunately, some of these locational details are puzzling. Kia Ora is east of the Kakanui River, on a flat with surrounding low hills, none of which exceed 150 m. Despite the written and sketched details it is still not possible to place the site exactly on a modern map. The valley in question had a road through it (Fig. 2), and one possible valley with a road, is at grid reference 375707 (NZMS260 J41; T.H. Worthy, pers. comm. 2003). It is even possible that the Kia Ora site and the one called “Five Forks” (Worthy 1998: 503) are the same, since the grid reference given for the latter is the bed of a stream and cannot be correct (T.H. Worthy, pers. comm. 2003). The two sites are clearly close by, if not the same. The Kia Ora site has the Geological Society of New Zealand Fossil Record Number J41/f251 (Worthy 1998).

Map of Moa-bone Site



Fig. 2. Sketch map by K.L. Warren, 1930, showing the location of the Kia Ora moa bone site (Auckland Museum Library MA 95/43/21, AV2.6.489).

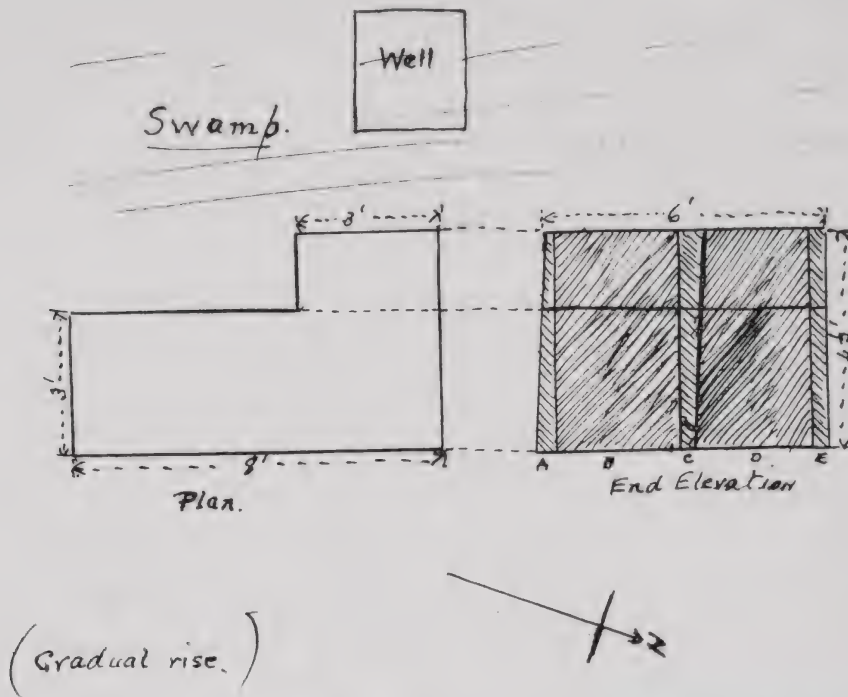


Fig. 3. Diagram by K.L. Warren, 1930, showing his excavation at Kia Ora (Auckland Museum Library MA 95/43/21, AV2.6.489).

DISCOVERY

Warren first recovered bones from the site in April 1930, accompanied by Mr Skinner of Otago Museum. Warren gave some bones to the farmer, and to Otago Museum, but the museum declined further involvement and referred him to Auckland Museum. Archey offered Warren remuneration of £6 per week to dig bones for a fortnight during the college vacation in September, plus expenses in packing and forwarding the bones to Auckland. Archey visited the site for one day in September (probably on the 5th), and presumably gave directions for the excavation. The dig took place during the first fortnight in September but was cut short when rain flooded the hole. Warren felt he obtained a representative collection, but that he “touched only the fringe of the deposit”.

Warren’s diagram (Fig. 3), shows that he excavated an area of about 28.5 square feet (2.7 m²) to a depth of 6 feet (1.8 m). He identified the following five strata (Fig. 3):

Layer (A): Surface clay and soil, 4–9 inches (100–230 mm) deep.

Layer (B): “Peat clay”, 3 feet (910 mm) deep. No bones but “fresh-water mussels and minute shells”.

Layer (C): Ash and charcoal, 4–6 inches (100–150 mm) deep. Bones poorly preserved and mostly broken.

Layer (D): “Blue-pug clay”, 2 feet (610 mm) deep. Bones in good condition; also timber, mussels, stone, water-worn shingle.

Layer (E): Black sandy silt; depth unknown. Bones poorly preserved but whole.

After the second excavation, the moa bones were washed and sent to Auckland by coastal

steamer from Oamaru. When received by the museum on 1 October, the bones were placed in a skylight to dry out.

MOA FAUNA

At the first dig, in April 1930, Warren recovered leg and toe bones, vertebrae, ribs, three skulls and chick bones, all indicative of “many species and ages”. When the final collection was received, Archey identified most of the bones as belonging to *Pachyornis elephantopus*, *Emeus crassus*, *Emeus buttonii* (= *E. crassus*) and *Euryapteryx gravis* (= *Eu. geranoides*), with a few assigned to *Anomalopteryx didiformis* and species of *Dinornis* (Auckland Museum register “Moa Record”). T.H. Worthy checked the identity of nearly all the Kia Ora specimens and attributed most to *Emeus crassus* and *Euryapteryx geranoides*, and a few to *Pachyornis elephantopus*, *Dinornis struthoides* and possibly *D. giganteus* (Worthy 1998: 507).

The inventory below largely follows Worthy’s determinations. A very large mandibular fragment (formerly 441; now B11083) matches a reference specimen of *D. giganteus* and I have assigned it to that species. A long but very slender tarsometatarsus of a chick (formerly 416) I have identified as *Dinornis struthoides* and re-numbered B11082.

L. Huynen (Massey University, Auckland) amplified DNA from a small sample drilled from each of three femurs of *Emeus crassus* (B6106). Initial results have confirmed a right femur 282 mm long as belonging to *E. crassus*, but the other two femurs (264 and 284 mm long) have DNA sequences that group them with specimens of *Euryapteryx geranoides* (D. Lambert and L. Huynen, pers. comm. 2003).

M. Bunce (Oxford University, U.K.) amplified DNA from a sample taken from each of two tibiotarsi of *Euryapteryx geranoides* (B6138 and B6237), and found the DNA sequences to confirm that identification (M. Bunce, pers. comm. 2003).

INVENTORY OF SPECIMENS

Bones in Auckland Museum believed to be from the 1930 Kia Ora site are currently registered in the 50 lots listed below. They are mostly catalogued from Kia Ora without further details (except for three lots labelled from “Beck’s farm”). Some of the bones are pale, but most are stained brown or black, which is consistent with a swamp origin. B6799 and B6800 (both tibiotarsi of *Dinornis struthoides* labelled “North Otago”) are assumed to be from the Kia Ora collection because B6800 and B6785 (from Kia Ora) seem to be a pair, matching exactly in size, shape, colour and wear.

In total, 332 bones from Kia Ora are recognisable in the Auckland Museum collection, representing a minimum of 51 individual moas. Table 1 gives summary statistics for the largest samples of leg-bone measurements.

Pachyornis elephantopus (Owen, 1856)

(8/3; minimum number of individuals based on the three sizes of tarsometatarsi)

B5940 (formerly 283; x/y = 1/1). L tibiotarsus (467 mm).

B5980 (formerly 422; 1/1). L femur (315 mm).

B5981 (formerly 422; 1/1). L femur (304 mm).

B5982 (formerly 422; 1/1). R tarsometatarsus (250 mm).

B5983 (formerly 422; 1/1). L tarsometatarsus (215 mm).

B5984 (formerly 422; 1/1). R tarsometatarsus (214 mm).

B5985 (formerly 422; 1/1). L tarsometatarsus (210 mm).

B6239 (formerly 285; 1/1). R tibiotarsus (540 mm).

***Emeus crassus* (Owen, 1846)**

(97/17; minimum number of individuals based on 17L femurs)

B6091 (formerly 442; 11/4). 2 crania; 3 premaxillas; 4 mandibles (some partial); 2 quadrates.

B6101 (formerly 422; 1/1). R tarsometatarsus (227 mm).

B6106 (formerly 415; 13/7). 6L+7R femurs (237, 255, 261, 264*, 271, 280, 282, 282, 284*, 287, 289 mm). One immature. *DNA analysis suggests that these two femurs belong to *Euryapteryx geranoides* (D. Lambert and L. Huynen, pers. comm. 2003).

B6107 (formerly 415; 17/9). 8L+9R tibiotarsi (413, 424, 431, 432, 448, 471, 471, 476, 478, 480, 485, 486, 501 mm).

B6130 (formerly 415; 16/10). 10L+6R tarsometatarsi (184, 202, 208, 208, 212, 217, 221, 222, 223, 228, 229, 232, 233, 234, 242 mm). One immature.

B6131 (formerly 416; 4/2). 2L+2R tibiotarsi (387, 387 mm). Two immature.

B6132 (formerly 416; 14/9). 9L+5R femurs (203, 236, 241, 243, 245, 247, 248 mm). Five immature.

B6133 (formerly 416; 8/6). 2L+6R tarsometatarsi (143, 158, 177, 185, 188, 189, 192 mm). Two immature.

B6232 (formerly 287; 5/4). 4L+R tarsometatarsi (183, 187, 190, 196, 197 mm).

B6236 (formerly 285; 6/4). 2L+4R femurs (286, 289, 293, 296, 297, 307 mm).

B6238 (formerly 285; 2/1). 2L tibiotarsi (481, 512 mm).

***Euryapteryx geranoides* (Owen, 1848)**

(81/12; minimum number of individuals based on 12L femurs or 12R tibiotarsi)

B6136 (formerly 422; 4/2). 2L+2R tibiotarsi (513 mm).

B6137 (formerly 422; 1/1). R femur (275 mm).

B6138 (formerly 415; 1/1). R tibiotarsus (400 mm).

B6139 (formerly 415; 1/1). R tibiotarsus (413 mm).

B6140 (formerly 416; 1/1). L femur (213 mm). Immature.

B6141 (formerly 416; 1/1). L femur (201 mm). Immature.

B6178 (formerly 441; 21/8). 8 crania; 4 premaxillas; 8 mandibles or mandibular fragments (minimum number of individuals = 4); quadrate.

B6229 (formerly 287; 4/3). 3L+R tibiotarsi (397, 414 mm).

B6230 (formerly 287; 7/5). 5L+2R femurs (242, 244, 244, 245, 263, 266 mm).

B6231 (formerly 287; 3/2). L+2R tarsometatarsi (186, 196 mm).

B6234 (formerly 285; 13/9). 4L+9R tarsometatarsi (187, 188, 211, 212, 212, 213, 214, 219, 219, 219, 221 mm). One immature.

B6235 (formerly 285; 11/6). 5L+6R femurs (285, 286, 289, 294, 302, 308, 309 mm).

B6237 (formerly 285; 13/7). 6L+7R tibiotarsi (466, 467, 479, 480, 493, 503, 510, 513, 514, 515, 531 mm).

***Dinornis struthoides* Owen, 1844**

(22/5; minimum number of individuals based on 5L or 5R tarsometatarsi)

B6287 (formerly 285; 2/1). L+R femurs (306 mm).

B6288 (formerly 415; 1/1). R femur. Immature.

B6289 (formerly 416; 1/1). R femur (215 mm). Immature.

B6784 (formerly 413; 1/1). R tibiotarsus (594 mm).

B6785 (formerly 413; 1/1). R tibiotarsus.

B6791 (formerly 414; 7/4). 3L+4R tarsometatarsi (304, 309, 312, 314, 334 mm).

B6792 (formerly 414; 2/1). L+R tarsometatarsi (238 mm).

B6799 (former number not recorded; 1/1). R tibiotarsus.

B6800 (former number not recorded; 1/1). L tibiotarsus. Seems to make a pair with B6785.

B7062 (formerly 11; 4/1). Premaxilla; mandibular fragment; quadrate; uncinat process.

B11082 (formerly 416; 1/1). L tarsometatarsus. Immature.

***Dinornis giganteus* Owen, 1844**

(2/1)

B6360 (formerly 432; 1/1). L femur. Damaged.

B11083 (formerly 441; 1/1). L proximal mandibular fragment.

Unidentified moas

(122/13)

B5677 (formerly 417; 5/3). 3R tibiotarsi (351 mm); L+R tarsometatarsi (160 mm). All immature.

B6179 (formerly Moa 18.15; 107/9). 4 sesamoids; 82 non-ungual phalanges; 21 ungual phalanges. Largest phalanx is 105 mm long.

B7128 (former number not recorded; 2/2). 2 sterna. Both large.

B7129 (former number not recorded; 4/4). 4 sterna. All large.



Fig. 4. Mrs Halcombe's moa egg (AIM B4016) in 1961, after its rescue from the house fire in New Plymouth. The egg is held by a neighbour. *Taranaki Herald* photograph (Taranaki Museum ARC2002–45).

B7130 (former number not recorded; 4/4). 4 sterna. Three large; one small.

AGE

The North Otago swamp sites are all undated but they are assumed to sample primarily Holocene faunas (Worthy 1998).

MOA EGG, B4016

Gill & Cooper (2001) described and illustrated a large fossil egg (approximately 208 mm long by 134 mm in diameter) that was broken but held together by sediment, and that seemed to be a moa's egg. When Ron Lambert of Taranaki Museum, New Plymouth, read the article he recognised the egg as having been in the collection of Mrs Blanche Stuart Halcombe (Fig. 4).

The egg and other items were bequeathed to Auckland Museum after Mrs Halcombe's death in a house-fire in 1961. Blanche Halcombe was a grand-daughter of William Swainson, the naturalist and illustrator, who emigrated to New Zealand from England in 1841.

Among the Halcombe papers at Taranaki Museum is a hand-written copy of a letter dated 27 May 1939 (ARC2002-58) to "Cousin John", presumably from Blanche Halcombe, which states "My brother got a moa's egg (dredged up at Cromwell)". This appears to establish a precise locality for the egg (Cromwell, Otago), and agrees with the prediction of an eastern South Island locality from petrographic analysis of the associated sediment (Gill & Cooper 2001). A letter from Halcombe (née Turton) to J.C. McLean dated 9 June 1911 (Auckland Museum Library MS181, Box 3, Folder 17) mentions the egg, establishing that it was collected sometime before 1912. The photo of the egg in 1961 (Fig. 4) shows it in the glazed case with green velvet lining in which it was stored at Auckland Museum until the 1980s.

DISCUSSION

The 280 bones, from a minimum of 19 moas, currently representing the Clevedon site in the Auckland Museum collection are far short of the 34 birds reported by the *N.Z. Herald* in 1912, or the 900 bones representing 40–50 birds reported by Oliver (1949: 14). Earlier reports may have been inaccurate, but it is more likely that after the finders' protracted attempts to sell the collection, Auckland Museum received only part of the original collection. Certainly the *Dinornis* skeleton (Fig. 1) is not among the Clevedon bones listed here.

Large numbers of *Anomalopteryx didiformis* at the Clevedon site, with fewer *Pachyornis mappini* and *Dinornis struthoides*, are evidence of a moa fauna typical of North Island wet forest sites (Worthy & Holdaway 2002: 193), the presence of tall podocarp forest being indicated by the numerous seeds of large forest trees. Likewise, the moa fauna at Kia Ora, dominated by *Emeus crassus* and *Euryapteryx geranoides*, is similar to that of other North Otago swamp sites (Worthy 1998: 471), and typical of lowland sites in the dry eastern South Island (Worthy & Holdaway 2002: 197).

Some Kia Ora bones are outside the size-range for the species they are assigned to, in terms of the sizes given by Worthy (1988) and Worthy & Holdaway (2002). For example, a tibiotarsus of *Pachyornis elephantopus* (B5940; 467 mm) is too small (published range 500–620 mm). However, some bones from latest Holocene sites extend these published size limits. For example, Worthy (1998: table 5) gave the size range of tibiotarsi of *P. elephantopus* from Otago as 425–606 mm, which accommodates B5940.

It is likely that several of the Kia Ora bones are misidentified. The femurs of *P. elephantopus* and *Eu. geranoides* are acknowledged to be difficult to distinguish (Worthy 1988: 13), as are the tibiotarsi of *Eu. geranoides* and *E. crassus* (Worthy 1988: 24–25). Preliminary DNA analysis of three femurs from Kia Ora assigned to *E. crassus* (B6106) suggests that two belong instead to *Eu. geranoides* (D. Lambert and L. Huynen, pers. comm. 2003), and high-lights the problem. I have removed these two bones from the sample in Table 1, but other bones are almost certainly misidentified, and the data should be regarded as approximate.

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